Verifying the Agreed Framework: Executive Summary

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Background Materials for the 2nd Workshop of the Joint CISAC-CGSR Project
To Evaluate Security and Safeguards of the DPRK's Nuclear Reactors
Under the Agreed Framework of 1994

Verifying the Agreed Framework

Under the 1994 Agreed Framework (AF) between the United States and the Democratic People's Republic of Korea (DPRK), the U.S. and its allies will provide two, large nuclear-power reactors and some other benefits to the DPRK in exchange for an agreement by the DPRK, *inter alia*,

- to declare how much nuclear-weapon materials it has produced
- to identify, freeze, and eventually dismantle specified facilities for producing this material
- to remain a party to the nuclear Non-Proliferation Treaty (NPT) and allow implementation of its safeguards agreement under the NPT.

This AF and associated agreements are now being carried out according to a complex and currently delayed schedule. Benefits have been provided to the DPRK, the site for the two nuclear-power reactors has been largely prepared, and the power reactors partially constructed. For its part, the DPRK has declared some nuclear-weapon material, and has identified and frozen some facilities for producing this material. The history and nature of the AF and other pertinent agreements, and what these agreements mean for safeguards, are described and analyzed in Chapters 1 and 2. The negotiating status of safeguards measures other than those agreed is also discussed.

Given the U.S. goal of nuclear non-proliferation on the Korean peninsula, central questions include the following: How verifiable are the AF and associated agreements? How well will the U.S. and its allies know that the DPRK has no access to nuclear-weapon materials? And how can this knowledge be improved upon? This report is devoted to answering these questions.

Our answers can be subsumed under three headings: one dealing with the nuclear-power reactors to be provided by the Korean Energy Development Organization (KEDO), one dealing with known or suspected DPRK nuclear-materials production facilities, and one dealing with possible adverse developments affecting verification and safeguards. These answers in turn provide the basis for some analysis of what the U.S. and its allies will and will not know under various, possible future circumstances. The report closes with such an analysis.

The Executive Summary briefly discusses the conclusions of this report, some of which are listed next:

- Assuming full cooperation by the DPRK, INFCIRC 153 safeguards provide reliable assurances of non-diversion nuclear materials for military purposes.
- Irreversible dismantlement of designated Yongbyon facilities will require removing or destroying certain process equipment and building infrastructure.
- Increased transparency of all nuclear-related activities in the DPRK is required to gain confidence that the DPRK does not have a nuclear-weapons program.
- Continued monitoring and surveillance of the frozen nuclear facilities at Yongbyon until dismantlement is essential to ensure there is no nuclear-weapons material production at this site.
- Evidence suggests the DPRK must amend its declaration and that continued delay of verification activities could adversely affect the success of the AF.
- Accelerating the schedule for verification activities and achieving compliance with the DPRK's safeguards agreement would be a significant confidence-building measure.

- Agreement on the removal and ultimate disposition of nuclear material from Yongbyon facilities and spent fuel from light-water reactors (LWRs) is an important milestone.
- Environmental monitoring and other INFCIRC 540 measures could increase confidence that there are no undeclared nuclear activities in the future.
- Full compliance by the DPRK with the NPT and its safeguards agreements is essential.

Safeguarding the Nuclear-Power Reactors Provided By KEDO

The two, large nuclear-power reactors to be provided by the U.S. and its allies under the AF are of a relatively well-understood type currently being built and operated by the Republic of Korea (ROK, or South Korea) and called the Korea Standard Nuclear Plant (KNSP). They are to be provided by KEDO, a consortium sponsored by the U.S. but mostly funded by South Korea. In what follows, we refer to them as KEDO Reactors 1 and 2. These reactors, the Kumho site in North Korea where they are being built, and their surroundings are described in Chapter 3.

The fresh nuclear fuel for these reactors contains no nuclear weapon-usable material. On the other hand, like all current nuclear-power reactors, these reactors produce reactor-grade plutonium[1] along with energy for electricity. Some of this plutonium is left in the highly radioactive spent nuclear fuel when that fuel is taken out of the reactors. The main objective of safeguards is to ensure that this plutonium is not diverted but stored and disposed of in accordance with the AF and applicable International Atomic Energy Agency (IAEA) rules, and thus does not end up in nuclear weapons.

The KNSPs have a well-developed and effective safeguards package agreed to between South Korea and the IAEA.[2] These safeguards comprise measurements, inspections, accounting procedures and other measures, detailed in Chapter 4. Safeguards are not fixed for all time, but are improved as time goes on. Current and prospective improvements, also detailed in Chapter 4, include environmental sampling of air, water, soil, and vegetation near inspection sites, and remote monitoring in real time of key entry points, locks, seals, power output, and other facets of reactor operations.

So long as this safeguards package (including the data-transmission system) is properly installed and maintained, the inspectors and technicians properly trained and kept up to date—and the IAEA not interfered with in carrying out its procedures—we conclude that it will be nearly impossible for plutonium-containing spent fuel to be taken out of the KEDO reactors covertly.

We consider overt and covert diversion and misuse scenarios in Chapter 5. As detailed there, we could not find credible covert diversion and misuse scenarios under the conditions stated above for the KEDO reactors. On the other hand, overt action to break out of the safeguards agreement is always possible. This is discussed in “Possible Adverse Developments” in the Executive Summary.

In reaching the above conclusion, we cannot overemphasize the importance of proper maintenance, training, continued unobstructed inspector access, and timely data transmission for the IAEA. In particular, the inspectors must be free to investigate any suspect activity at the reactor site. Because all future circumstances cannot be specified in advance, a degree of DPRK cooperation will be needed. Examples of what such cooperation would involve are specified in Chapter 8. If, on the other hand, the DPRK takes advantage of legalisms concerning the extent and frequency of special inspections, for instance, the effectiveness of safeguards could be degraded.

Safeguards do not end at the reactor site. After being taken out of the reactor, the highly radioactive, plutonium-containing spent fuel will spend some years in spent fuel pools under continuous observation by the IAEA, until its radioactivity has decayed sufficiently to allow its being placed into casks and either stored further or taken away. Provisions for that part of the process, which are some years into the future, have not been specified or agreed to in detail. Under the AF, the DPRK must allow removal of this spent fuel if the U.S. desires. Because it would be less hazardous to get the plutonium out of the spent fuel after its radioactivity has decayed a few years, it is important that adequate and verifiable provisions for its removal be made. Final or long-term storage of such spent fuel outside the DPRK is a problem that has not been resolved in East Asia and which is more political than technical.

Verification of DPRK Declaration and of Disposal and Dismantlement of Identified or Suspect Nuclear Facilities

Verifying the DPRK's declaration and of disposal and dismantlement of identified or suspect nuclear facilities is a more complex task than safeguarding the KEDO reactors. Neither the items to be verified, nor their initial condition are fully known ahead of time. The task may be broken down and analyzed as follows.

Verification of DPRK Declaration

The DPRK has declared the existence of seven facilities as subject to inspections, six at Yongbyon and one at Taechon:

1. two reactors that were in operation, one of which is subject to the freeze,
2. one reactor that remains incomplete,
3. a fuel-fabrication facility,
4. a radioisotope laboratory, and
5. a waste site.

There is also a reactor under construction at Taechon that remains incomplete.

Details, technical history, and pictures are in Chapter 6. Plutonium-containing fuel has been withdrawn from one of the reactor cores and is stored in cans in a nearby pool. The DPRK further declared that it had separated a small quantity (less than a hundred grams) of plutonium.

This declaration has been questioned considerably. At least one undeclared waste site has been identified, probably containing additional plutonium-containing wastes, and there is evidence (analyzed in Chapter 6) for more past fuel removal and more past plutonium-separation activity than the DPRK has declared. Under the circumstances, verifying either the initial DPRK declaration or some amended declaration (should amendment to the original declaration be considered acceptable under the AF) must entail unhindered measurements and inspections at all identified and suspect DPRK nuclear facilities.

The path forward for the IAEA to determine the correctness and completeness of the initial declaration has been developed, including planning for contingencies. It includes plans for the cases where large amounts of radioactive wastes are discovered in previously hidden waste sites. There is no plan to attempt to verify the accuracy and completeness of the initial declaration unless access to the two suspect waste sites is granted, if the agency stays with the recommendations of former Director-General Hans Blix. The IAEA plan is not public information. A review of the methods available to the IAEA (Chapter 4, Section 4.6) indicates that if all methods available to the IAEA, including additional measures under INFCIRC 153, are brought to bear, there would be

good confidence that past nuclear activities have been generally identified at all sites where the full panoply of IAEA measurements and inspections are allowed.

Verification of Disposal and Dismantlement of Identified Yongbyon Facilities

Not too much is known about the plans for disposing of the fuel, and no agreement has been worked out between the DPRK and the U.S. on exactly how the canisters will be shipped. The destination for the fuel is unknown as of now. Only the Sellafield plant in the U.K. currently has facilities specifically for handling the MAGNOX type of fuel used in the Yongbyon reactors.[3] So long as inspection of all spent fuel and separated material by the IAEA is continuous and unhindered, storage and disposal do not pose serious verification problems.

After the first KEDO reactor has been completed and the DPRK spent fuel has been removed from Yongbyon, the DPRK will be required to dismantle its frozen nuclear facilities. The IAEA has compiled considerable information regarding decommissioning, which should help the DPRK in the dismantling effort. Details of the usual process, which involves safe storage, entombment, and dismantlement, are given in Chapter 6. The major dismantlement challenge will be dealing with the radioactivity in the reactor and other facilities. There are procedures for this, but some years will be needed to carry them out. Some of the crucial pipes and the special equipment may have to be removed or destroyed early in the process to make the dismantlement verifiably irreversible.

Verification Regarding Other Suspect Facilities

There has been and may eventually again be facilities other than those at Yongbyon that come under suspicion of being used for nuclear-material production, storage, or other nuclear activities. These could pose a more serious verification problem than the Yongbyon facilities. Some of the additional methods under INFCIRC 153 discussed in Chapter 4, Section 4.6, notably environmental monitoring away from declared sites and special inspections at undeclared facilities, are needed to detect these facilities. Satellite monitoring by the U.S. is needed as well. With these tools, it is likely that any extensive nuclear activities would be detected. On the other hand, there could only be partial confidence that separated plutonium might not be secreted somewhere. Even partial confidence would require that the DPRK as a whole became transparent to ongoing inspections.

If DPRK accepted the new safeguards protocol (INFCIRC 540) under consideration by other countries including South Korea, as discussed in Chapter 2, there would be two possible advantages. First, inspectors could ask as a matter of right to inspect undeclared facilities, without requiring special approval by the IAEA's Board of Governors. This may or may not be much of a practical improvement over the present situation. Second, environmental samples could be taken at places other than within declared sites. There would also be a possible disadvantage if the new protocol were used to decrease frequency of inspections.

Possible Adverse Developments

Adverse developments are usefully considered in the framework of the time sequence of events envisaged by the AF. This time sequence, together with its implications for verification and safeguards, is analyzed in Chapter 7 and is summarized in the Executive Summary Table. The time sequence presented is not complete. A number of other important steps are linked into the time sequence. Some of them are discussed in the relevant chapters. The steps summarized in the table are those which require verification or safeguards or which bear on the timing of verification and safeguards. The

steps in the left-hand column are shown in time order. As actual dates have slipped and are likely to continue to slip, no dates are shown.

We note in connection with the sequence of steps in the table the crucial link between Steps 2 and 3, i.e., the IAEA declaring the DPRK to be in compliance, the delivery of nuclear components to the KEDO Reactor 1, and the necessary Agreement of Cooperation with the U.S. No Congressional review of an agreement of cooperation and no provision of nuclear components to DPRK is possible until the IAEA is satisfied that the DPRK's reports on all its nuclear materials and facilities are accurate and complete.

In Chapter 8, we analyze briefly five scenarios ranging from more complete cooperation from the DPRK than has been forthcoming to date, to the consequences of overt breakout by the DPRK from the AF and obligations under the NPT. We have analyzed what information will be available at what time for various scenarios of delays, non-cooperation and breakout. We also analyze a scenario under which the U.S. or the ROK does not carry out its part of the AF. These scenarios and their implications for verification and safeguards can be summarized as follows.

Executive Summary Table. Envisaged Time Sequence of Events.

Step	Verification Issue	Possible Problems
Partial completion and of first KEDO reactor in ROK and partial preparation of Kumho site in DPRK	None but IAEA wants to start next step early (2-4 years needed)	Financial and legal delays cause some loss of data at Yongbyon
IAEA declaration that DPRK is in compliance with its agreements	Verification of accuracy and completeness of the DPRK s initial report on all nuclear materials in the DPRK, at Yongbyon and possibly elsewhere	1. DPRK does not open suspect sites to IAEA. 2. IAEA activities are interfered with. 3. Initial report wrong-can it be amended?
Delivery of KEDO Reactor 1 key nuclear components starts. Transfer Yongbyon spent fuel (and other material?) to ultimate disposition starts.	Safeguards for KEDO Reactor 1 are installed. Transfer of Yongbyon spent fuel (and other material?) to ultimate disposition verified.	4. Disagreements over extent of safeguards. 5. Disagreements over site of disposition. 6. Disagreements over what is to be transferred
Simultaneous completion of previous steps	Safeguards on KEDO Reactor 1 operational. Disposition site monitored.	Same as previous, plus interference with KEDO Reactor 1 safeguards
Dismantlement of Yongbyon facilities in parallel with delivery of KEDO Reactor 2 key nuclear components	Safeguards for KEDO Reactor 2 are installed. Dismantlement verified.	1. Disagreements over extent of safeguards. 2. DPRK abrogation. 3. U.S. or ROK non-compliance with AF.
Simultaneous completion of previous steps	Safeguards on KEDO Reactor 2 operational	4. Interference with safeguards. 5. DPRK abrogation.
Disposition of KEDO spent fuel	Monitoring disposition site(s)	Disagreement over site of disposition

Further Delays

Delays have occurred and are likely to continue to occur for a variety of legal, financial, and political reasons. A number of these reasons are noted in the various chapters. Delays before any KEDO reactor is completed puts off the eventual IAEA declaration of DPRK's compliance and the attendant knowledge of what material and facilities the DPRK actually has and will jeopardize some IAEA measurements. On the other hand, verification that the DPRK does not have a program at Yongbyon at least is not affected by delays so long as the Yongbyon site continues to be verifiably frozen.

Delays after either or both KEDO reactors are completed, for instance, in the DPRK allowing special inspections or environmental monitoring could have more serious consequences, and are taken up under abrogation below.

Non-Cooperation with IAEA Verification of Compliance

DPRK cooperation has been limited to date, as detailed in the text, and has not eased the IAEA's task. Limited or lack of cooperation on the part of the DPRK has much the same effect as delays at this stage of the AF. Non-cooperation at Yongbyon and other possible sites of past activities has taken the form of not allowing access by IAEA inspectors to undeclared suspect facilities, limiting IAEA measurements where inspectors are allowed, and preventing off-site environmental monitoring. Continuation, either in the form of outright denial or undue delay, would have the effect, under the AF, of preventing delivery of key nuclear components for KEDO Reactor 1 to the DPRK. Again, verification that the DPRK does not have a program at Yongbyon at least would not be affected by such continued non-cooperation so long as the Yongbyon site continues to be verifiably frozen. The ability of the IAEA to verify the initial DPRK report would decay to an extent that depends on the techniques to be used and that we cannot fully assess. It would not disappear over the next several years. Verifying that no activities were carried out at other locations would require special inspections at these other locations.

Need for Amended DPRK Declaration

If the IAEA is allowed to carry out inspections and measurements at Yongbyon and at such other sites as may be needed as detailed in Chapter 6, the IAEA could conclude that more plutonium-containing fuel or more separated plutonium exist in the DPRK than the DPRK originally reported. In that case, it would become an issue for negotiation between the U.S. and the DPRK whether an amended DPRK declaration would be allowed under the AF, assuming the DPRK to be willing to amend its original declaration. From a verification point of view, the situation would be better than it is now, in that the U.S. and its allies would have more complete and reliable knowledge of the DPRK's nuclear material and facilities than it has now, and more complete ongoing safeguards over such material and facilities would be possible.

Disagreements Over Material To Be Transferred from the DPRK

A verification issue would arise if the DPRK took a narrow view of what it was obligated to allow transferring out of the country under the AF, for instance, restricting transfer to spent fuel from specified Yongbyon facilities, rather than from suspect facilities such as described in Chapter 6. If these facilities had been identified and inspected, and nuclear material to be safeguarded found there, it seems unlikely that the DPRK would not allow its transfer, but it could occur under pretext of safety or environmental considerations. In that case, or in any case of disagreement over transfer of nuclear material, the IAEA would have to monitor the material in the DPRK on a

continuing basis. If the DPRK were to abrogate the AF in the future, it would regain access to this material.

Such disagreement could bring the AF to an end. Because, however, transfer takes place simultaneously with the installation of key nuclear components in KEDO Reactor 1, it is highly desirable that full agreement be reached regarding what materials are to be transferred including material that may be found in suspect but not identified facilities.

Disagreements Over the Site of Ultimate Disposition

So long as the sites of ultimate disposition for the DPRK's nuclear material are outside the DPRK and otherwise acceptable to the U.S., no verification issue is likely to arise from disagreements over this issue, except that such disagreements could prolong the time that the material remains in the DPRK, and that the IAEA has to monitor it. Again, such delays would mean that, if the DPRK were to abrogate the AF during that period, it would regain access to this material. It is highly desirable that full agreement be reached regarding the site of ultimate disposition before the KEDO reactors come on line.

Disagreement Over Extent of Safeguards for KEDO Reactors

In Chapters 2, 4 (especially Section 4.6.1), and 5, we discuss in some detail additional measures that the IAEA can take over and above the measures in place at most reactors, but still within the INFCIRC 153 package of safeguards. These include remote monitoring, environmental sampling, and other recommended steps. Remote monitors can record entry / exit information, monitor nominal reactor operations in redundant ways, check on the movement (or non-movement) of nuclear material, and detect interference with containment or tampering with IAEA safeguards devices, samples, or data. Some of these methods are in the demonstration stage in the ROK, and some still need development. All require reliable means of transmission, as well as automated review and analysis of acquired data. Several enhancement measures, now in demonstration stage, could be applied to the data transmission program.

Beyond the INFCIRC 153 safeguards lie some desirable extended measures. Among those, for instance, is environmental monitoring of air and water away from declared sites. While environmental sampling cannot provide one-hundred percent certainty of detecting covert or illegal activities, it faces a prospective diverter with a significant chance of detection, particularly if diverted material is not simply transported and stored, but is involved in some industrial process. The utility and practicality of environmental sampling in and around nuclear facilities have been validated through the conduct of field trials at the invitation of a number of NPT parties.

Though the older package of safeguards has proven its worth, the new measures discussed in the previous two paragraphs, together with the enhancement measures for the data transmission, would add significantly to assurance of compliance. The specific package to be implemented at the KEDO reactors has to be negotiated and disagreements could occur over application of these safeguards. Many of the safeguards measures which it would be desirable to install in the DPRK are being demonstrated in the ROK. Successful negotiations for installing extended safeguards, whether within or beyond INFCIRC 153, in the DPRK will depend on similar measures being implemented into the ROK. In general, the role of the ROK is crucial in the safeguards area as well as in all other aspects of the KEDO program. Given that the new measures are increasingly being tested and adopted in many countries, however, and given that some of them can give early warning of illicit activity, disagreement over cooperation on this issue could constitute a warning sign of either past activities or possible future intent to divert.

Interference with Safeguards for KEDO Reactors

Once safeguards have been agreed to and are operational, interference with their operation in any form (e.g., denial or delay of needed access, late or incomplete records, interference with transmission of data, unreliable power supply, interference with updating of equipment) could seriously affect the assurance that nuclear material, in particular spent fuel, is not being diverted. The seriousness would depend on the details of the particular situation, but it would be particularly damaging to verification if it occurred after the initial refueling, when the initial load of spent fuel contains plutonium that would be particularly attractive for weapons use (see Chapter 5 for reasons and details). The fuel initially discharged contains enough plutonium to make 10–20 nuclear-explosive devices, for instance, of the type tested in 1945 at Trinity. Spent fuel must spend several years in cooling ponds under the safeguards described in detail in Chapter 4, Section 4.5 before it can be moved. Once it is removed from the pool building, it must remain the subject of continuing safeguards in the DPRK until it is removed from the DPRK, at which time safeguards appropriate to the new location will be imposed. This location is likely to be the ROK and removing spent fuel from the DPRK is thus likely to depend on having storage facilities in the ROK.

Abrogation of AF or NPT After the KEDO Reactors Are Installed

No safeguards can prevent such overt acts such as the abrogation of agreements and expulsion of inspectors. In the case of abrogation, the U.S. would know how much potential nuclear-weapon material there is in the DPRK initially. It would, as now, externally monitor such large-scale activities as continued reactor operations, construction of facilities, and to some extent identification of major activities, as discussed in Chapter 4, Section 4.6. With some of those techniques, it would be possible to estimate how much plutonium is made in reactor operations subsequent to abrogation. Handling the radioactive spent-fuel rods and separating the plutonium would be major operations (see Chapter 8) requiring distinctive facilities, albeit those might be hidden underground. Once the facility is built and the procedures practiced (without actually having light-water reactor (LWR) spent-fuel assemblies available for realistic tests), however, the time needed to separate several bombs' worth of material might be only days or weeks if all went according to plan. In practice, however, the time needed is likely to be much longer. The IAEA's Standing Advisory Group on Safeguards Implementation has estimated that the time required to convert plutonium in spent fuel into a weapon is one to three months, compared to seven to ten days for metallic plutonium.

Organization of Report

Chapter 1 provides a brief history of the DPRK's nuclear program and its interactions with the IAEA and other countries. A summary and analysis of the AF and related agreements that are now or will be in force is offered.

Chapter 2 summarizes the safeguards and how they are applied under existing agreements. Possible additional agreements that the IAEA has reached with other countries are also discussed.

Chapter 3 describes the KEDO reactor site, nuclear reactor activities in East Asia, and related issues such as fuel shipment and electricity provision.

Chapter 4 provides a detailed description of the KEDO reactors and the safeguards expected to be applied the under the present agreements, together with some complementary verification measures.

Chapter 5 describes diversion and misuse scenarios for light-water reactors, such as the KEDO reactors, and their possible consequences.

Chapter 6 provides a description of known and suspected nuclear-related facilities in the DPRK, specifically at Yongbyon and Taechon, and of the methods that can be used to assess how much plutonium has been produced and separated.

Chapter 7 summarizes the sequence of activities envisaged by the AF and notes what there will be to verify and what measures of verification will take place as the agreement is carried out.

Chapter 8 examines the process of implementation under assumptions of varying degrees of DPRK cooperation or obstruction.

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In this report, the authors do not take a position on the desirability of the AF, the future of the DPRK, or the desirable U.S. policy in these matters. It is likely that views on these matters differ among the individual authors. The report is solely an assessment of safeguards and verification.

Executive Summary Notes

1. While reactor-grade plutonium is not ideally suited for weapons, it can be used to construct them.

2. The IAEA is charged by the NPT with verifying that nuclear facilities of non-nuclear-weapon NPT parties are used for peaceful purposes—not to make nuclear weapons. The actual measurements and accounting practices used for such verification are called “safeguards.” The safeguards agreements of non-nuclear-weapon NPT parties are modeled on published guidelines called INFCIRC 153. The particular safeguards agreement between the IAEA and the DPRK is INFCIRC 403.

3. MAGNOX fuel readily corrodes and is unsuitable for long-term storage or geologic disposal. Reprocessing is the only viable solution for disposition of spent MAGNOX fuel.